School of Earth Sciences

Uplift and Erosion in Taiwan and its effect on CO_2 and C consumption

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1. Abstract

High Standing Islands (HSIs) experience extremely rapid physical and chemical weathering, resulting in large inputs of both sediments and solutes into the ocean. This can impact the global carbon cycle by the rapid burial of organic C and precipitation of calcium carbonate in the oceans. This poster will provide a progress report on a study of the role of uplift and erosion rates of various regions in Taiwan and its effect on the CO_2 and C consumption rates of the area. Taiwan sits on top of a highly active convergent plate boundary between the Eurasian and Philippine Sea Plate, which is the cause of the intense uplift that creates the orogenic mountains that make up the island. The plate margin has uplift rates >10mm/yr and contains erosional features dominated by mass-wasting. The island also contains three of the nine rivers in the world which have average sediment concentrations >10g/l (Milliman and Syvitski,1992). Soil samples from locations on the island subjected to a range of uplift rates will be analyzed for carbon (C), carbonate (CO_3), and particle size in order to determine whether variations in soil residence times can impact chemical weathering and CO_2 sequestration. I expect there to be a higher amount of CO_2 and C consumption on the island than most anywhere on Earth due to the readily weathered surfaces that result from the rapid uplift and fast erosion rates of the island.

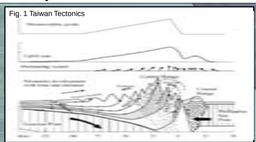
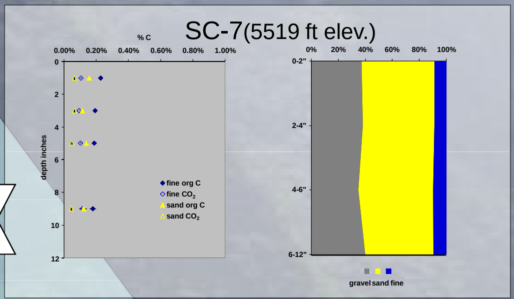


Fig. 1 Taiwan Tectonics



2. Background

Previous studies on weathering rates of high standing islands (HSIs) have shown some of the highest observed rates of chemical weathering (Lyons et al., 2005; Carey et al., 2005). However, attempts to correlate these rates to sources have often suffered due to a lack of ample soil geochemical data. Furthermore, few studies have attempted to determine a relationship between soil organic carbon content, storage, and sequestration with uplift and erosion rates.

The purpose of my research is to determine organic and inorganic carbon content in soils from regions with different uplift and erosion rates. This information will be combined with existing data on water and sediment geochemistry to determine total carbon stores on the island and flux to the ocean as a result of physical and chemical weathering.

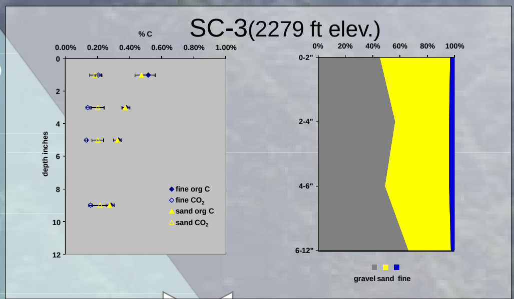


Table #1: Sample Location Summary

Map Key	Sample Location	Lithology*	Uplift Rates†	Erosion Rates‡
1	Fushan Experimental Forest	Sandsotne, shale, argillite, phyllite, slate, quartzite	5-10 mm yr^{-1}	2-8 mm yr^{-1}
2	Yuan-Yang Lake	shale, argillite, phyllite	5-10 mm yr^{-1}	3-6 mm yr^{-1}
3	Choshui Watershed	Sandstone, mudstone, shale, argillite, phyllite	5-10 mm yr^{-1}	3-10 mm yr^{-1}

*Ho, 1988
†Shin and Teng, 2001
‡Dadson et al., 2003

3. Geologic Setting and Sample Location

- The central range formed by oblique collision of the Eurasian plate beneath the Philippine Sea plate
- Uplift rates >10mm yr^{-1} have been recorded (Shin and Teng, 2001)
- Rapid uplift of the region leads to high rates of physical erosion by mass-wasting, which allows fresh rock to be exposed for subsequent chemical weathering
- Three out of nine rivers in world, which have annual sediment concentrations >10g/l (Milliman and Syvitski, 1991)
- Samples were collected from three locations in Taiwan with varying degrees of uplift and erosion rates (See Figure 1 & Table 1)

4. Sampling Methodology and Analysis

- Samples were initially dried for 96 hrs at 110ºC
- Organic and inorganic carbon were determined by loss on ignition method. Samples were heated at 550ºC for 4 hrs to determine the amount of organic carbon and at 950ºC for 1 hr to determine the amount of carbonate (Heiri et al., 2001)
- Samples were also sieved to determine variation in particle size
- Changes of organic and inorganic carbon were plotted within each soil profile

5. Results

Initial results show soil samples to be dominated by sand and gravel particle sizes. Clay sized particles comprise only a few percent of the total soil in these sites. Inorganic carbon (CO_2) concentrations were low and ranged from ~ 0.1 to 0.2%. Concentrations did not vary systematically with depth or with particle size for any of the soils analyzed.

The organic carbon content was highest in the surface samples from the Fushan Experimental Forest for both the fine and sand sized fractions. Surface concentrations ranged from ~ 0.5 to 1% and then decreased with depth to ~ 0.2% in the sediment profiles analyzed.

Soil organic carbon contents from the Yuan-Yang Lake and Choshui site were much lower, ~ 0.1 to 0.3%.

Organic carbon concentrations in the gravel size fraction for all the sites measured were low and relatively constant with depth, ranging from ~ 0.15 to 0.25%.

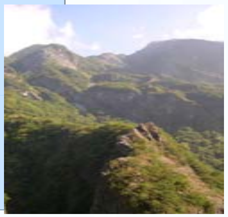


Fig. 2 Key

1. Fushan Experimental Forest:
- SC(1-6), 2251-2641 ft. elev., moderate slope

2. Yuang-Yang Lake:
- SC(7-10), 5519-5705 ft. elev., steep slope

3. Chosui Watershed:
- SS(C,J,R,S,andY), 311-1028 ft. elev., gentle slope

FIG. 2 RIVERS AND WATER RE... REGIONS OF TAIWAN

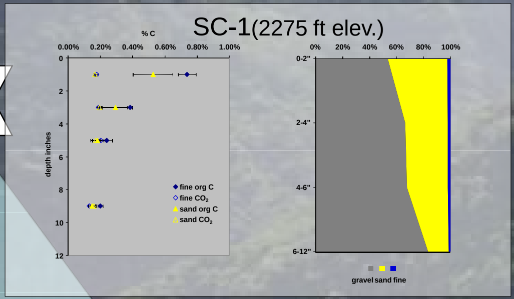
6. Discussion

The soils are predominately composed of the larger size fractions, with little clay, and very low concentrations of carbonate and organic carbon, indicating that they haven't experienced extensive chemical weathering. However, as evident from the previous studies in the area (Lyons et al., 2005; Carey et al., 2005) the rapid uplift and erosion rates will remove the more weathered material, exposing fresh rock that is rapidly chemically weathered.

Total inorganic carbon sequestered in soils in the study areas is equivalent to ~ 1 kg/m² soil. This is the same amount of CO_2 that would be emitted from driving my car to school.

Total organic carbon sequestered in the soils is equivalent to ~1 to 3 kg/m² soil. This would allow me to drive to work and back all week.

However, erosion rates coupled with total carbon content of the soils, yields carbon flux rates of 30kg/m² soil/century. This would be equivalent to a billion metric tons of CO_2 sequestered from the island in the last century.



7. Future Research

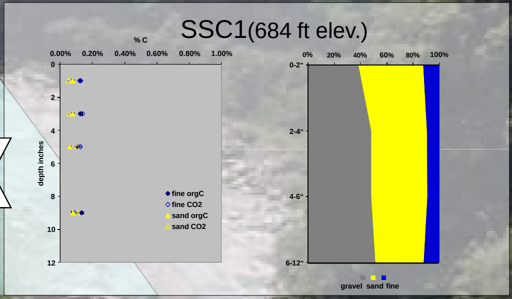
Bulk Chemistry analysis:
- Age of soil
- Composition
- Extent of chemical alteration

Determine variability in organic and inorganic C stores as a function of elevation, slope, and lithology

Experimentally determine weathering rates of materials to determine reactivity of different size fractions

Role of biosphere on weathering rates by analysis of carbon isotopes

Investigate episodic extreme weathering events associated with typhoons



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Google Earth

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